UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/936,818	02/28/2002	Koji Takahashi	829-585	1578

23117 7590 09/10/2003

NIXON & VANDERHYE, PC
1100 N GLEBE ROAD
8TH FLOOR
ARLINGTON, VA 22201-4714

EXAMINER	
SONG, MATTHEW J	

ART UNIT	PAPER NUMBER
1765	

DATE MAILED: 09/10/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)
	09/936,818	TAKAHASHI ET AL.
	Examiner	Art Unit
	Matthew J Song	1765

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Peri d f r Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *26 June 2003* .

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *29-141* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *29-141* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____ .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other:

DETAILED ACTION

Claim Rejections - 35 USC § 102

1. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

2. Claims 29-32, 34-36, 45-48, 61-66, 68-70, 82-85, 90, 98-103, 105-107, 119-122, 132, and 140-141 are rejected under 35 U.S.C. 102(b) as being anticipated by Adomi et al (US 5,442,201).

Adomi et al discloses growing an epitaxial layer of a compound semiconductor alloy doped with nitrogen and represented by the formula $(Al_xGa_{1-x})_yIn_{1-y}P$ ($O < x \leq 1$, $0 < y \leq 1$). Adomi et al also teaches using NH_3 as a nitrogen doping source and the presence of organic aluminum is considered to contribute to efficient nitrogen doping, allowing a higher amount of nitrogen doped (col 2, ln 1-65). Adomi et al also teaches a light emitting device is fabricated by growing an n-type AlGaP layer **4**, an N-doped AlGaP layer **3**, an N-doped AlGaP layer **2** and a p-type AlGaP on a GaP substrate **5** (col 2, ln 66 to col 3, ln 5 and Fig 1). Adomi et al also discloses the n-type AlGaP layer **4** is formed by supplying a mixed source gases of TMAl, TMGa and PH_3 at a growth temperature of 850°C. Adomi et al also discloses the larger AlP molar ratio of an alloy AlGaP tends to have higher nitrogen concentration in the AlGaP when the NH_3 concentration is the same, resulting in more efficient nitrogen doping and it is extremely hard to dope nitrogen in GaP without the presence of TMAl (col 3, ln 6-67 and Fig 4). Adomi et al also discloses MOVPE is used as the epitaxial growth method and other methods such as CBE (chemical beam

epitaxy) can be used (col 4, ln 1-67). Adomi et al also teaches nitrogen is doped to GaP layers near a p-n junction to substitute P sites in order to improve the light emitting efficiency (col 1, ln 20-35).

Referring to claim 29-30, Adomi et al discloses Al increases the efficiency of nitrogen doping and organic aluminum, i.e. vapor phase, is considered to contribute to efficient nitrogen doping (col 2, ln 25-35), this reads on applicant's decomposition of ammonium and adsorption of nitrogen is accelerated. Furthermore, Adomi et al discloses supplying ammonia and Aluminum to a substrate surface as applicant, therefore the addition or crystallization of the nitrogen from the ammonia which is supplied to the surface of the crystal into the surface of the crystal is accelerated by the aluminum supplied to the surface of the crystal is inherent because Adomi teaches a similar process of supplying aluminum and ammonia to form a nitrogen in a crystal.

Referring to claim 31, Adomi et al discloses an AlGaP layer doped with nitrogen, where the Al inherently exists throughout the layer, including the surface.

Referring to claim 32, Adomi et al discloses in Fig 4 that a larger molar ratio of AlP of an AlGaP alloy tends to have higher nitrogen concentration, this reads on applicant's an amount of nitrogen added to a crystal, a nitrogen composition, an amount of nitrogen adsorbed and amount of an element in the crystal surface is controlled by the Al. Also these would be inherent to Adomi et al.

Referring to claim 34, Adomi et al discloses CBE and MOVPE (col 4, ln 35-50). Adomi et al does not disclose MBE, MO-MBE or GS-MBE. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Adomi by using MBE, MO-MBE

or GS-MBE, which are well-known equivalent method of deposition to CBE and MOVPE. Substitution of known equivalents for the same purpose is held to be obvious (MPEP 2144.06).

Referring to claim 35, Adomi et al discloses AlGaP:N (Fig 1) and P reads on applicant's Group V element other than nitrogen.

Referring to claim 36, Adomi et al discloses Phosphorous. Adomi et al does not disclose Arsenic or antimony. Arsenic, antimony and phosphorous are well-known Group V elements, used in the manufacture of Group III-V compound semiconductors. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Adomi et al by using Arsenic or antimony, which are well-known equivalents to phosphorous for the manufacturing of III-V compound semiconductors. Substitution of known equivalents for the same purpose is held to be obvious (MPEP 2144.06).

Referring to claims 45-46, Adomi et al discloses a GaP substrate (Fig1). Adomi et al does not disclose a substrate of GaAs, InP, GaSb or Si, which are well-known substrates used in the formation of Group III-V compound semiconductors. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Adomi et al by using a GaAs, InP, GaSb or Si substrate because substitution of known equivalents for the same purpose is held to be obvious (MPEP 2144.06).

Referring to claim 47-48, Adomi et al teaches a nitrogen doped epitaxial layer is an active layer and a light emitting device (col 1, ln 50-68 and Fig 1)

Referring to claim 63 and 100, Adomi et al teaches growing an AlGaInPN crystal, supplying NH_3 to a surface and the larger AlP molar ratio of an alloy of AlGaP tends to have a higher nitrogen concentration, this reads on applicant's adsorption of the nitrogen atom

generated by decomposition of the ammonium supplied to the surface of the crystal is accelerated by the aluminum included in the surface of the crystal. Furthermore, Adomi et al discloses supplying ammonia to a substrate surface containing aluminum as applicant, therefore decomposition of the ammonium supplied to the surface of the crystal is accelerated by the aluminum included in the surface of the crystal is inherent because Adomi teaches a similar process of supplying ammonia to the surface of an aluminum containing crystal to form nitrogen in a crystal.

Claim Rejections - 35 USC § 103

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

4. Claims 34, 37-39, 42-44, 49-50, 53-60, 68, 71-76, 79-81, 86-87, 92-97, 105, 108-109, 112-113, 116-118, 123-126 and 133-139 are rejected under 35 U.S.C. 103(a) as being unpatentable over Adomi et al (US 5,442,201) as applied to claims 29-32, 34-36, 45-48, 61-66, 68-70, 82-85, 90, 98-103, 105-107, 119-122, 132, and 140-141 above, and further in view of Tomomura (WO 98/44539), where US 6,358,822 is used as an accurate translation and a translation of WO 98/44539 can be provided upon request.

Adomi et al teaches all of the limitations of claim 37, as discussed previously, except a substrate temperature of 450-640°C.

In a method of growing a Group III-V compound semiconductor, note entire reference, Tomomura teaches a Group III-V compound semiconductor layer including nitrogen and at least another Group V element grown by molecular beam epitaxy and is grown by irradiating a substrate with material molecular beams in crystal growth chamber so evacuated that the mean free path of material molecules is larger than the distance between the substrate and molecular beam sources, a nitrogen compound is used as a nitrogen source and moleuclars of the nitrogen compound decompose after they reach the substrate surface and only nitrogen atoms are incorporation into the growing semiconductor crystal (abstract). Tomomura also teaches a nitrogen hydride, NH_3, is used as the nitrogen compound and the substrate temperature is maintained at 500-750°C during crystal growth ('822 col 3, ln 1-50). Tomomura also teaches the substrate is a compound semiconductor which as a zinc blend structure and the substrate surface has an off-angle of 5-15° from {100} plane to a {111}A plane and decomposition is promoted and high incorporation efficiency of nitrogen is achieved on this substrate surface ('822 col 3, ln 50 to col 4, ln 5). Tomomura also teaches Al, Ga and In molecular beams were directed to a substrate by heating a solid metallic material using a Knudsen cell ('822 col 5, ln 10-55). Tomomura also teaches incorporation efficiency of nitrogen into the crystal can be improved ('822 col 4, ln 5-35). Tomomura also teaches GSMBE, CBE and MOMBE ('822 col 15, ln 1-30 and col 1, ln 5-55). Tomomura also teaches a timing chart for supplying reactant gases in sequence and one cycle of the source supply sequence is set in a range of 0.5 to 5 molecular layers to form a mixed crystal with uniform composition ('822 Fig 6 and col 10, ln 25-67).

It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Adomi et al with Tomomura method of forming Group III-V compound

semiconductor at a temperature of 500-750°C to improve incorporation efficiency of nitrogen into a crystal and the operating lower temperatures reduces operating costs.

Referring to claim 34, Tomomura teaches MBE, GSMBE, CBE and MOMBE ('822 col 1, ln 10-25).

Referring to claim 37, Tomomura teaches a temperature of 500-750°C. Overlapping ranges are held to be obvious (MPEP 2144.05).

Referring to claim 38-39, 74-76, and 112-113, Tomomura teaches the substrate surface has an off-angle of 5-15° from {100} plane to a {111}A plane, this reads on applicant's surface slanted from a (100) surface in a [011] direction or a crystal face which is equivalent.

Referring to claim 42, Tomomura teaches an evacuated chamber and a mean free path of a molecule of each source material is longer than a distance between the substrate and a source material ('822 col 2, ln 50-67).

Referring to claim 43, Tomomura teaches solid sources in Knudsen cells.

Referring to claim 44, Tomomura teaches a nitrogen compound decomposed at the growth surface ('822 col 3, ln 1-10)

Referring to claim 53-54, the combination of Adomi et al and Tomomura teach III-V compound semiconductor active layer used in a laser for optical fiber communication, this reads on a system ('822, col 1, 25-40).

Referring to claim 73, Tomomura teaches the nitrogen material and the material of the group V elements are not supplied at the same time in Fig 6.

5. Claims 40-41, 51-52, 77-78, 88-89, 91 and 114-115 are rejected under 35 U.S.C. 103(a) as being unpatentable over Adomi et al (US 5,442,201) as applied to claims 29-32, 34-36, 45-48, 61-66, 68-70, 82-85, 90, 98-103, 105-107, 119-122, 132, and 140-141 above, and further in view of Ito (Empirical interatomic potentials for nitride compounds semiconductors).

Adomi et al teaches all of the limitations of claim 40, as discussed previously, the semiconductor layer A including at least aluminum and nitrogen in it composition but not including indium in its composition and the semiconductor layer B including at least indium in its composition but not including nitrogen in its composition.

Ito teaches versatility of empirical potentials with AlN for various monolayer superlattices with InP or InAs (Abstract). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Adomi et al with Ito superlattice of AlN and InP or InAs monolayers because superlattices reduce lattice mismatch strain between layers.

6. Claims 33, 67, 104, 110-111 and 127-131 are rejected under 35 U.S.C. 103(a) as being unpatentable over Adomi et al (US 5,442,201) as applied to claims 29-32, 34-36, 45-48, 61-66, 68-70, 82-85, 90, 98-103, 105-107, 119-122, 132, and 140-141 above, and further in view of Motoda et al (US 5,872,022) and Ouchi (JP 10-152399), where US 6,046,096 is used as an accurate translation and a translation of JP 10-152399 can be provided upon request.

Adomi et al teaches all of the limitations of claim 110, as discussed previously, except etching the layered structure while masking a portion of the layered structure such that the first semiconductor layer is exposed in a portion of an etch surface and supplying ammonium to the etched surface.

In a method of forming a compound semiconductor structure, note entire reference, Ouchi teaches a portion of a compound semiconductor is irradiated with material including at least nitrogen and a group V element of the irradiated portion is substituted with nitrogen (abstract). Ouchi also teaches a GaAs substrate **501,** a grating **502** formed on the substrate and performing a nitrification process around a recess portion to form a large number of InGaAsN quantum wires **505** along the recess portion at a substrate temperature of 800°C ('096 col 10, ln 35 to col 11, ln 5 and col 7, ln 20-35 and Fig 5). Ouchi also teaches when substitution by nitrogen is selectively conducted and a semiconductor layer containing nitrogen and layer without nitrogen are formed in a distributed pattern, a fine structure, such as a quantum wire can be readily fabricated ('096 col 11, ln 10 to col 12, ln 25). Ouchi also teaches improved characteristics, such as low threshold, is achieved by a device with a quantum wire structure ('096 col 6, ln 1-50). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Adomi with Ouchi's selective nitrification to form a quantum wire structure to improve the characteristics of the device.

In a method of forming a semiconductor device, note entire reference, Motoda et al teaches a diffraction grating process, where an insulating film is formed on a diffraction grating layer **25,** a stripe-shaped diffraction grating pattern **32** is formed and used as a mask. Motoda et al also teaches the diffraction grating layer is etched, thereby forming a groove having a (111) facet surface and producing a diffraction grating (col 16, ln 30 to col 17, ln 45 and Figs14(a)-14(f)). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Adomi et al and Ouchi with Motoda et al's method of forming a grating by etching because deposition and etching to form the grating can be

performed in the same apparatus to avoid oxidation of the oxidation and contamination, which is detrimental to the device (col 2, ln 1-35).

Referring to claim 33, the combination of Adomi et al, Ouchi and Motoda et al teach forming a diffraction grating pattern, where nitrification occurs in a recessed portion, this reads on applicant's restricted region.

Referring to claim 110, the combination of Adomi et al, Ouchi and Motoda et al teach forming a grating pattern by etching and supplying ammonium to a substrate to substitute a constituent element in the first semiconductor layer in a layered structure.

Referring to claim 111, Motoda et al teaches a (111) surface.

Referring to claim 127, the combination of Adomi et al, Ouchi and Motoda et al teach a diffraction grating and a periodic wire structure at a ½ of the pitch of the grating ('096 Fig 5) and substitution of nitrogen.

Referring to claim 128, the combination of Adomi et al, Ouchi and Motoda et al teaches a quantum wire.

Referring to claim 129, the combination of Adomi et al, Ouchi and Motoda et al teaches ammonium.

Response to Arguments

7. Applicant's arguments filed 6/26/2003 have been fully considered but they are not persuasive.

In response to applicant's argument that the references fail to show certain features of applicant's invention, it is noted that the features upon which applicant relies (i.e., supplying

aluminum and ammonium **directly** onto the surface of a crystal) are not recited in the rejected claim(s). Although the claims are interpreted in light of the specification, limitations from the specification are not read into the claims. See *In re Van Geuns*, 988 F.2d 1181, 26 USPQ2d 1057 (Fed. Cir. 1993). The instant claims do not require directly supplying reactant, merely supplying reactants to a surface of a crystal.

Applicant's argument that Adomi teaches using an intermediate product produced by reaction within gaseous phase between ammonium and an organic compound of Al without employing the surface of the substrate is noted but is not found persuasive. Applicant alleges that Adomi teaches forming an adduct, therefore discloses an intermediate product, however, this is not the case. Adomi discloses, "we **believe** an adduct is formed between NH_3 and TMAl and the chemical bonding between Al and N plays an important role when N is doped in AlGaP, note column 3, lines 61-65. Adomi merely believes an adduct is formed; he does not teach an adduct is actually formed. Also, Adomi teaches a chemical beam epitaxy as a method of supplying similar reactants to the surface of the substrate, as applicant, which is claimed to be a method of supplying reactants to the substrate surface, note instant claim 34 and page 43, ln 15 to page 44, ln 15 of the instant specification. Furthermore, chemical beam epitaxy (CBE) is well known in the art to be a method of **irradiating a substrate** with molecular beams of source materials, note Tomomura (US 6,358,822) col 1, ln 10-25.

In response to applicant's arguments against the references individually (claims 42-44), one cannot show nonobviousness by attacking references individually where the rejections are based on combinations of references. See *In re Keller*, 642 F.2d 413, 208 USPQ 871 (CCPA 1981); *In re Merck & Co.*, 800 F.2d 1091, 231 USPQ 375 (Fed. Cir. 1986). Adomi does not

teach the mean free path limitation, the limitation is taught by Tomomura. Also, Adomi does not require an intermediate product, as discussed previously. Tomomura teaches MBE, CBE and MOMBE for a method of manufacturing a III-V compound semiconductor by **irradiating a substrate** with molecular beams of source materials ('822 col 1, ln 10-25).

Conclusion

8. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

9. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Matthew J Song whose telephone number is 703-305-4953. The examiner can normally be reached on M-F 9:00-5:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nadine Norton can be reached on 703-305-2667. The fax phone number for the organization where this application or proceeding is assigned is (703) 872-9306.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-308-0661.

Matthew J Song
Examiner
Art Unit 1765

MJS

NADINE G. NORTON
PRIMARY EXAMINER